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Dissertation

on

Respiration,

by

Amos Pennebaker

of

Pennsylvania.

To

William Gibson, M.D.
Professor of Surgery in the University
of
Pennsylvania,
this
Dissertation
is
Dedicated,

With sentiments of the highest
Respect and Esteem,
By
Amos Pennebaker.

Respiration.

The blood, after having been sent by the left ventricle of the heart through the arteries to every part of the body, for its nourishment and support, is again returned, by the veins, to the right auricle of the heart, and supplied with chyle; but, before being distributed over the system, it is necessary that it should be brought in contact with the atmosphere, that it may undergo certain changes, by which it is deprived of its superabundant quantity of carbon: for this purpose there is a complicated apparatus called respiratory, consisting of the larynx, trachea and lungs.

The larynx is composed of five cartilages, which form an irregular tube that opens upwards, corresponding to the posterior nares; the inferior portion is connected to

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the trachea, which is placed in the fore part of the neck, anterior to the œsophagus. It is a hollow tube, cylindrical in front, but flat on its back part, consisting of a number of cartilaginous rings that form about two thirds of the circumference of a circle anteriorly, the third behind, where there is a deficiency in the rings, is filled up by an elastic fibrous membrane which is also placed in the intervals between the rings and serves to connect them together. When the trachea passes into the thorax, it inclines a little backwards and enters the posterior mediastinum, and divides into two branches opposite the third dorsal vertebra, one going to the right, the other to the left lung. These branches are again subdivided into smaller ones which, together with the two main branches, are na-

-ned bronchia. The internal surface of the bronchia, as well as the larynx and trachea are lined by a soft elastic mucous membrane.

After having mentioned in a cursory manner, the canal and its branches, by which a communication is established between the lungs and external air, it may be proper to describe the lungs. The bronchia already mentioned divide into a great number of branches which ramify in the lungs in every direction, and now assume the appearance of small membranous tubes, having attached to their extremities vesicles or cells, which differ from the common cellular texture of the lungs and other parts of the body. It is in these cells that the atmosphere effects the necessary changes on the blood which is conveyed to them

by the pulmonary arteries. These arteries take their origin at the base of the right ventricle by a common trunk, that soon divides into two branches, one entering at the root of the right lung, the other at that of the left; when they again divide and subdivide, so as to become small capillary vessels, which ramify around the air cells in such a manner as to form a net work around them, and then they inosculate with a set of capillary veins; these unite with one-another, and at length form two large trunks for each lung, from which they emerge to discharge their blood into the left auricle of the heart, after having been subjected to the atmosphere in the delicate vessels around the air cells.

Besides the pulmonary arteries there are others for the nourishment of the lungs

arising from the aorta, these are the bronchial arteries which penetrate the different tissues of these viscera, and finally terminate in the bronchial veins; those of the veins which belong to the right lung discharge their blood into the vena azygos, and those which be-
-long to the left, into the subclavian vein. The lungs are also furnished with a great number of absorbent vessels that arise from their internal substance, as well as from their external surface. They are directed in their course towards the bronchial glands, which are of a blackish colour and placed around the bronchia, where they enter the lungs. Lastly, the lungs are supplied with nerves which are principally derived from the par vagum and intercostal.

Those different tissues are united togeth-
-er by an intermediate cellular tissue,

which not only serves to connect them together, but is also useful in keeping the vessels of these organs from encroaching upon each other.

The lungs thus constituted of arteries veins, lymphatics, et. ct, present the appearance of two large spongy bodies of an irregular conoidal shape, each one, is divided into lobes by fissures, the left consisting of two, and the right of three; they are also inclosed by a serous membrane, each lung having one that may be compared to an impervious sack, one side of which serves to line the lung and is designated pleura pulmonalis, and that side or portion of the sack which lines the cavity of the chest is named pleura costalis.

The thorax, in which the lungs are placed, has in shape some resemblance to

a cone, the apex of which is above, and the base below; the posterior portion is formed by the dorsal vertebræ, and its lateral sides by twenty four ribs, twelve being placed on each side, and articulated behind with the vertebræ; before, the seven that form the superior section of the chest articulate with the sternum, a bone that is somewhat tri angular in form; these bones form an in-casement for the protection of the heart and lungs, and have attached to them, at various places, muscles for increasing and diminishing the capacity of the chest, and a variety of other purposes. There is also a circular muscle called diaphragm, attached to the outline of the base of the chest, that forms a partition between the viscera of the thorax and those of the abdomen.

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The atmosphere is so intimately connected with the function of respiration, that a consideration of some of its ~~most~~ chemical and physical properties are essentially necessary to a perfect understanding of the manner in which venous blood is transformed into arterial. It is that aeriform fluid which every where surrounds the earth to the height of a considerable number of leagues; it is invisible, colourless, without odour, and only sensible to the touch when in motion; it has the property of compressibility; for a portion may be made to diminish greatly in volume by pressure, and as soon as the pressure is removed it will resume its former bulk, proving also that it possesses elasticity. There is another property in atmospheric air, namely its weight, which may be

ascertained by exhausting a vessel, and counterpoising it on a scale beam, and then by allowing the air to rush in, it will be found that the end to which the vessel is attached will preponderate considerably. It is owing to its gravity that it presses equally on every part of the earth's surface: its pressure is about fifteen pounds to every square inch. It must be obvious that the strata of air which are near the earth's surface sustain a greater weight than those that are a considerable distance from it, and as it is compressible, those portions which are below must be more dense than those which are more elevated. These variations in the density of the atmosphere have no influence on the functions of the human body when near the earth,

but when man ascends to the tops of high mountains, where the pressure of the air is not so great, and consequently it must be lighter and rarer, a remarkable effect is produced on some of the animal and mental functions; owing to the diminished pressure on the surface of the body and deficiency of oxygen, there is a sudden exhaustion of muscular power, palpitations of the heart, throbbing of the arteries, universal weakness, accompanied with a propensity to sleep, respiration becomes laborious; lastly, hemorrhage takes place from various parts of the body.
These derangements serve to show the necessity of the atmospheric pressure; for if its pressure were removed, it would be impossible for our bodies to remain in the state in which we see

them; the fluids would be determined to their external surfaces, and thereby de-range the internal functions; hemorrhage would also take place from ~~various~~ internal parts that are but slightly protected by linings like the mucous membranes.

I shall now proceed to the chemical properties of the atmosphere. It was supposed to be an element, till the discovery of oxygen, when its real composition was ascertained by Scheele and Lavoisier, though they differed with regard to the quantity of oxygen it contained. Lavoisier, according to his analysis, fixed it at 27 mea-~~sures~~sures; Scheele supposed the quantity to be still greater. Subsequent to that time, it has been analysed by different chemists with more precaution, and, agreeably to the best authority, the proportions

of the different gases are represented to be about 21 of oxygen by measure, nitrogen 77.5; besides these gases, there enter into the composition of the atmosphere some carbonic acid and moisture; the quantity of carbonic acid is, by measure, 0.08, and that of aqueous vapour 1.42: these are the constituents that compose the atmosphere, and it must be evident from the analysis that has just been stated, that nitrogen forms the greater part of its bulk, which is a colourless gas destitute of taste or odour, and may be better distinguished from other gases by its negative properties than any peculiar character it possesses: it does not support life or combustion, yet when inhaled into the lungs, it produces no injurious effects on them. It was at one time supposed that its use

was merely to dilute the oxygen, but it is more probable that it may serve some important purposes of which we are unacquainted, for it has been proved by experiment, that respiration can be carried on without its being mixed with oxygen and that when an animal respires pure oxygen, there is no more or less consumed than if it were used in a state of mixture with nitrogen. Oxygen, like nitrogen, is colourless, transparent, without odour or taste; but possesses the property of supporting life and combustion, and enters into all animals and vegetable matter. It is this gas to which the air owes its chemical properties, for, when deprived of it, it will cease to support life or combustion; metals when heated in it will no longer become oxydized,

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as when oxygen is present. When the necessity of air is experienced, a number of muscles are called into action, by which the capacity of the chest is increased; the air, as has already been mentioned, presses on every part of the body, owing to its gravity, therefore, when a vacuum is formed in the lungs and their canal, it will consequently rush into them; this constitutes the process denominated inspiration. It is again expelled or expired by the action of another set of muscles, which by their contraction diminish the capacity of the chest, and thereby produce the process named expiration. The number of inspirations in a given time vary considerably in different individuals, and also in the same person, ~~per~~ ~~[illegible]~~, for a man that respires twenty times in a minute at one time, may at

another respire more frequently or not so often; the number is greatly influenced by a variety of circumstances, such as sleep, violent exercise, and moral affec-tions. There is another circumstance con-nected with inspiration that is not un-worthy of notice, namely, the quantity of air that enters the lungs at each inspira-tion. Various estimates have been made by different physiologists, but without com-ing to a uniform conclusion: thus by Goodwin, it has been stated to be 12 cubic inches, by Cuvier 16 or 17, and by Gregory 2. while Doctor Thompson thinks it to be 40 cubic inches; he also thinks that the same amount is expired, and that there is generally about 280 in the lungs. The air by traversing the nasal cavities, mouth, larynx, trachea and

bronchia has its temperature increased so as to be equal with that of the body; it must therefore become rarer and expanded, so as to increase in volume by the time that it enters the lungs: besides these changes it becomes mixed with vapour as it passes along the mucous membrane of the air passages.

After having mentioned the manner in which the air gains access to the lungs, and the slight changes it undergoes, it will be my next object to notice the chemical and physical changes it has undergone while in the lungs: In a few seconds after its introduction into these organs, a quantity, equivalent to that inspired, is expired, though probably not the same that has just been introduced in the preceding inspi-

-vation, however, whether it be the same or not, it is very evident that it has undergone certain alterations, for instead of the same quantity of oxygen that had been introduced, we find it greatly diminished, while the nitrogen has suffered neither increase nor diminution in bulk. The carbonic acid has also undergone a change with regard to quantity, for it will be found to have increased so as to represent the quantity of oxygen that has disappeared, which was 0.21 when inhaled, but now there remains only 0.18. or 0.19. while the carbonic acid amounts to 0.3 or 0.4. The air that is expired also is mixed with vapour, which most probably exhales from the capillary vessels that ramify around the air cells. It has been supposed that

the pulmonary exhalation is equal to the cutaneous; the extent of surface from which pulmonary exhalation takes place, and the fact that cutaneous exhalation is in an inverse ratio with the pulmonary, seem to warrant the conclusion.

"The transformation of venous blood into arterial — the venous blood is conveyed from the right ventricle of the heart to the lungs by the pulmonary arteries, and has to pass through their minute ramifications around the air cells; it then passes into the radicals of the pulmonary veins; while thus traversing these capillary vessels it is brought in contact with the atmosphere in the air cells, and by parting with its carbon is converted into arterial blood, which will be found to be q. c.

scarlet red colour, and to have a stronger odour than the venous, differing likewise from the venous in being possessed of a higher temperature, and the property of a more rapid coagulation; it has also a greater specific gravity, and contains less serum. The changes that take place in the air and blood, when brought together in the lungs, having been described, I shall next endeavour to show how some of them take place. It has already been mentioned that there is a portion of vapour mixed with the air that is expired; the formation of this vapour is owing to an exhalation from the capillary branches of the pulmonary arteries, and will most satisfactorily account for the diminution of serum in the blood during respiration. The change of colour has been attributed to iron in the blood, but it is

more probable that this alteration, as well as its increase of odour, depends upon the disengagement of carbon from it. As regards the manner in which this takes place, various opinions are entertained by physiologists; some supposing that the carbon is transmitted through the capillary parietes into the air cells, and that it there combines with the oxygen, forming carbonic acid, while others again suppose that the oxygen is absorbed by the blood through the capillary vessels, and that the carbonic acid is formed in them and afterwards passes into the cells. Besides the chemical actions mentioned, there are vital ones which have a considerable influence on the blood during respiration; it is owing to the conjoint agency of these two actions that the blood changes its venous character in the lungs. A P